CHANGES IN THE ULTRAVIOLET SPECTRUM OF EG ANDROMEDAE

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ABSTRACT

Ultraviolet observations of EG Andromedae, a symbiotic star, are reported which clearly show pronounced eclipse-like effects on the high-temperature far-UV continuum. Continuum and emission-line variations with phase are reported and related to synoptic Hα data. System parameters are characterized.

Subject headings: stars: combination spectra — stars: eclipsing binaries — ultraviolet: spectra

I. INTRODUCTION

EG And (HD 4174) is a peculiar, high-velocity object classified as an early M giant star on the basis of its optical spectrum (Babcock 1950). Ultraviolet observations reveal a strong, high-temperature emission-line spectrum, similar to that seen in symbiotic and related stars (Stencel and Sahade 1980; Slovak 1980; Friedjung and Viotti 1982). Smith (1980) demonstrated a 470 day variation in the equivalent width, radial velocity, and profile of Hα in the spectrum of EG And. The phase of maximum Hα EW is given by JD 2,443,200+470E. Stencel (1982) found pronounced changes in its UV spectrum near the predicted 1981 minimum Hα strength (phase 0.6). These data were used to suggest that EG And is an eclipsing binary symbiotic system, containing a red giant and a hot companion. The purpose of this Letter is to provide further evidence to this effect and to alert observers to the next favorable eclipse event in 1985 September so that ground-based and space-based photometry and spectroscopy can be pursued.

This Letter reports on ultraviolet and optical spectroscopy over a 5 month interval in 1982–1983 bracketing the predicted Hα minimum. The new data appear consistent with the idea of eclipse of the hot source and its associated material by the cool giant star. If verifiable, EG And, with its high galactic latitude may make EG And a potential candidate for detection in the extreme-ultraviolet. The evidence suggests that the bulk of the spectral flux in this, as in other symbiotics, emerges in that spectral region.

II. OBSERVATIONS

Observations of the ultraviolet spectrum of EG And spanning the 1150–3200 Å region were obtained with the International Ultraviolet Explorer (IUE) satellite (Boggess et al. 1978) using uniform 15 minute exposures with the low-resolution (6 Å) mode. Table 1 lists the particulars of the new data. The sequence was terminated by the encroachment of the satellite's solar avoidance zone over the stellar position. The ultraviolet spectrum, at other than phase 0.6, is characterized by bright resonance and intercombination emission lines superposed on a hot continuum. The continuum slope and the visibility of continuum shortward of Lyman-α to the 1150 Å sensitivity cutoff can be interpreted, prior to dereddening, as a blackbody with a temperature in excess of 30,000 K. The presence of C iv, Si iv, and possible N v emission lines argues for moderate density regions of 50,000–125,000 K. A weak, rising continuum was detected in the LWR camera, longward of the Mg II 2800 Å emission feature. This continuum might be due to the 3700 K red giant photosphere. However, the flux varies (albeit by a smaller amount than in the far-UV), suggesting both eclipsed and uneclipsed sources contribute. Balmer continuum emission from an accretion disk seems a likely contributor (see § IIId below). The monochromatic continuum fluxes and the integrated emission-line fluxes listed in Table 1 were measured using standard software provided at the IUE Regional Data Analysis Facility at the Goddard Space Flight Center.

The two most obvious changes in the UV spectrum of EG And near predicted Hα minimum (phase 0.6) can be seen in Figure 1: (a) the disappearance of the continuum within a 0.1 phase interval, and (b) disappearance of the He II 1640 Å line within a few hundredths phase interval. The continuum shape at phases 0.54 and 0.57 implies an increasing opacity which may be continuous and/or associated with Lyman-α, as suggested by details of the continuum symmetry about the geocoronal Lyman-α emission feature.

III. DISCUSSION

a) Line Flux Variations and Opacity Structure

As can be seen from inspection of Table 1 and Figure 1, while the continuum flux declines smoothly, some of the line variations, especially He II 1640 Å, are complex. Assuming 10% measurement error for unsaturated lines in the IUE low-dispersion mode, the semiforbidden lines show monotonic...
Phase decreases, except N iv] 1485 Å. N iv], as well as Si iv/O iv] 1400 Å and He ii 1640 Å, shows a decrease between phases 0.41 and 0.54 but then increases in flux at phases 0.57 and 0.60, followed by a sharp flux decline at phase 0.64 (particularly He ii, which vanishes altogether). Mg ii 2800 Å appears to show the inverse tendency—weakest at phase 0.57 and 0.60, but strengthening at phase 0.64. This pattern of variation suggests thermally different regions of an asymmetric structure (perhaps a stream and/or hot spot?) being sequentially eclipsed and then revealed.

b) Relevance of Hα

Smith (1980) noted that the radial velocity of the peak of the Hα emission varied from −120 km s\(^{-1}\) near phase zero (maximum strength) to −20 km s\(^{-1}\) near phase 0.6. Correspondingly, the emission equivalent width changed from 6.5 Å to 0.5 Å. He also pointed out that the emission profile evolves from a strong symmetric one at phase zero, to one which then develops a blueward asymmetry which progressively erodes the emission until a weak double-peaked feature remains slightly above continuum level near phase 0.6. On the basis of the ultraviolet results, it seems plausible that the change results from an absorption enhancement due to increasing neutral hydrogen column density along the line of sight, as the hot object moves behind the extended atmosphere of the red giant star. Phase coverage of profiles provided by Smith was too sparse to infer the existence of alternative, asymmetric structures, such as streams. The variations found in the ultraviolet emission lines may support this latter topology, but more complete phase coverage of Hα variations would prove useful for confirmation.

c) Possible Inverse P Cyg in N iv]

There is a suggestion at phase 0.54 (verified with inspection of the photowrite that it is not an artifact/particle hit, etc.) that the N iv] emission profile shows a redshifted absorption component not present at other phases. This profile, if confirmed in subsequent orbits, presumably is telling us about mass motions in the intervening material (stream). Inverse P Cyg in N iv] was reported in high-resolution UV observations of RX Pup by Kafatos, Michalitsians, and Feibelman (1982). For a reversal to be resolved in the low-resolution EG And data, the implied velocity separation is large, roughly 750 km s\(^{-1}\).

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continuum effects in eclipse when the W-R star was in front of the O star, and a comparable decrease in the emission-line fluxes. They concluded that an appreciable contribution to the line emission arose from the volume occupied by stellar winds, and that much of the emission may originate between the stars. In contrast, Holm, Panek, and Schiffer (1982) found that in the nova-like variable UX UMa, while the continuum was strongly eclipsed, the lines were invariant. They speculated that the lines originate in an ionized cavity in the wind, again in a volume that is large compared with the Roche lobe of either star, to avoid eclipse effects. These models may partially apply to the hybrid case of EG And.

f) Comparison to Other Symbiotics

The low-dispersion UV spectra of EG And show a strong continuum variation probably due to eclipse, as well as pronounced spectral line strength changes, with Mg II and He II being the most pronounced. Although the observational coverage was not as intense as that provided for CI Cyg (Stencel et al. 1982), some interesting parallels can be drawn. The depth of eclipse for the intercombination lines (C III, N III, O III, and Si III) are comparable in the two systems. The resonance lines of Si IV and C IV also appear to behave similarly. The He II vanishes in EG And while it does not in CI Cyg. Mg II has a variation strongly tied to secular variations that are long compared with the eclipse in CI Cyg. In EG And, the Mg II strength also decreases, but the secular component is poorly determined because of infrequent observations.

Recent ultraviolet observations of AR Pav by Hutchings et al. (1983) are less easy to relate to EG And because of the lack of an eclipse of the hot object in AR Pav. The difficulty lies in the fact that the well-defined optical eclipses of AR Pav lack an unambiguous ultraviolet counterpart. Extended and variable emission regions were invoked to interpret the situation for AR Pav. Simpler eclipse geometry appears to suffice for EG And.

New high-dispersion observations, which are useful in discriminating the velocities of emitting material in EG And, along with a preliminary model for the system will be reported on separately.

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REFERENCES